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EFFECTS OF VARYING THE PERCENTAGE OF COMBER WASTE ON THE QUALITY OF COTTON YARN

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FOREWORD

This is a preliminary report based on a limited number of tests of the effects of varying the percentage of comber waste in the manufacture of combed cotton yarns. The tests indicate possibilities of conserving supplies of the longer staple cottons and at the same time reducing operating costs in mills producing combed yarns. Although subsequent tests may yield results that differ somewhat from those presented herein, it is believed that the general trends brought out in this study will be fairly stable regardless of the cotton used. In view of the immediate practical significance of these preliminary findings to combed yarn manufacturers, publication of the results seems to be justified under existing circumstances. The report will have served its purpose if it stimulates experimentation on the subject by combed-yarn manufacturers.

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INTRODUCTION

Combing is a mechanical process used in the manufacture of fine cotton yarns and in medium and coarse numbers where exceptionally strong, clean, and smooth yarns are sought. In the series of operations preparatory to the actual spinning process, combing is accomplished between the carding and roving processes. Yarns spun from cotton that has been subjected to combing are designated as "combed" yarns, as distinguished from "carded"yarns. It is estimated that for the year 1941-42, approximately 1,600,000 bales, or almost 15 percent, of the total of about 11,200,000 bales consumed in the United States, were spun into combed yarns.

Generally speaking, medium-fine and fine yarns, or yarns of 45s to 50s counts and above, are combed. Many coarser numbers ranging from 20s to 40s, such as underwear and hosiery yarns, army uniform twill yarns, and crochet yarns, are also combed. Some cottons shorter than 1-1/16 inch staple are combed, and some longer than this staple are only carded.

1/ The spinning and fiber tests on which this manuscript is based were made by John M. Cook and staff, of the cotton testing laboratory of the Food Distribution Administration, at Clemson, S. C., in cooperation with the Clemson Agricultural College.

therefore, there is no distinct dividing line in this respect as regards staple length. It is probably true, however, that the bulk of the yarns spun from 1-1/8 inch staple and longer are combed, and that most of the shorter staples are carded.

The objectives of combing are to obtain stronger, cleaner, and smoother yarns. From a technical standpoint this is accomplished by removing much of the short fiber remaining in the cotton after carding; by freeing the cotton from such imperfections as neps and small particles of foreign matter that may have escaped the carding process; and by straightening the fibers and arranging them as nearly parallel as possible. To accomplish the removal of short fiber and imperfections, a considerable quantity of waste or "noils" is removed. This may range from less than 9 percent of the weight of the carded stock in some special cases to 25 percent or more in the spinning of very fine yarns. The straightening and parallelizing of the fibers is accomplished by passing rows of steel needles through the stock, and by "drafting" or attenuating the stock by means of pairs of rollers revolving at different rates of speed.

Combed yarn is usually cleaner, smoother, stronger, and more uniform than carded yarn spun from the same cotton. Combing is considered an essential process in the manufacture of sewing thread, which must be clean and smooth; of fine fabrics such as lawns and voiles in which a smooth, silky appearance is required; and of any fabric in which high strength and durability in proportion to weight are desired, such as army uniform twill fabric, airplane and balloon cloth, and many other types of cotton textiles needed for war purposes.

COMBER WASTE

In many ways the cotton comber is the most complicated, and thus the most remarkable, machine in a cotton mill. It is not, however, as nearly perfect as is frequently thought to be the case. The combed stock always contains a considerable quantity of short fibers, and, on the other hand, the comber waste always contains an appreciable proportion of long fibers. To effect an improvement in the quality of the product it is customary, after ascertaining that the machine is functioning properly, to increase the amount of waste that the machine will take out. This is done in one or more of several ways, involving changes in the settings and timing of the various machine parts. It is not necessary to discuss these adjustments or their relative effects and merits here. It is, however, important to note one point, namely, that the proportion of waste removed by the comber is, to a considerable extent, objective; that is, the percentage of waste is quite controllable, and is more or less independent of the quality of the cotton being processed.

Thus, a manufacturer of combed yarns has some leeway in determining how much of his cotton is to go into the product and how much into waste. Since the usual percentage of comber waste removed is relatively large, it is clear that the quantity of raw cotton consumed in the manufacture of combed yarns is, to an important extent, within the control of the manufacturer.

One of the largest single uses of combed yarns at the present time is in the manufacture of army uniform twill fabrics. The Government specifications for such fabrics do not set forth what percentage of comber waste shall be removed, but simply state that the yarns shall be "well combed." Accordingly, the amount of waste that is taken out is left entirely to the manufacturer, so long as he meets the fabric specifications. Therefore, in view of our limited supplies of long staple cotton, manufacturers may play an important part in conserving supplies of such cotton.

PURPOSE OF STUDY

What changes in the properties of the cotton and in the quality of yarn are effected by changes in the amount of comber waste removed in manufacturing? Is it more economical to change the percentage of comber waste or to use a different quality of cotton when changes in the quality of the yarn are required? Since available information on these matters is very sketchy and of questionable value, the manufacturer has been thrown on his own resources in predetermining the amount of waste that his combers should take out of the cotton.

An entirely different aspect of the general problem of comber-waste removal relates to the interpretation of the results of spinning tests made under controlled conditions in the laboratory. The tests made by the U. S. Department of Agriculture frequently involve the manufacture of combed yarns from groups of cotton representing different varieties. It is usually impracticable, in making these tests, to readjust the comber for each lot so that a predetermined percentage of waste will be removed. The result is that some variation in comber waste occurs among the different test lots, and it is not known to what extent this variation influences the results.

There is, therefore, a need for reliable information with respect to the effects of varying the percentage of comber waste removed in the course of manufacturing, on the quality of the yarn spun. It was the purpose of this study to obtain, by means of laboratory tests, as much pertinent data as possible with the time and facilities available, and to draw whatever conclusions the resulting data appeared to warrant.

To obtain complete answers to the questions under consideration would require a great volume of work involving the manufacturing and testing of many types of cotton. In the present case the time available for the study was very definitely limited, but it was thought that some valuable, although more restricted, results could be obtained through the use of a single sample of cotton.

DESCRIPTION OF TESTS

Because so much cotton is being used for combed army uniform twill, it was believed that cotton of the average quality used for such material would be most suitable for the tests. Available information indicated

that the cotton customarily used for this kind of fabric ranges from 1-1/8 to 1-3/16 inches in staple; therefore, a bale of cotton classed as 1-5/32 inches in staple was selected for the test. The bale was of Delta origin and was designated as Strict Middling in grade and Normal in character.

About 200 pounds of cotton was taken from the bale and passed through a hopper feeder and a vertical opener, and the opened lint was placed in a bin, where it was allowed to condition over night. Following this, the cotton was passed successively through the hopper feeder, breaker and finisher pickers, and card. A portion of the card sliver was set aside, later to be spun into carded yarns. The remainder was made into several sets of comber laps with the use of sliver and ribbon lappers.

The comber used in these experiments was a D-4 type, operating at a speed of 80 nips per minute. The quantity of waste removed was controlled by altering the setting of the cushion plate to the front detaching roller of the machine. Preliminary tests were conducted to determine the proper setting for each percentage of comber waste desired. As the regular tests were run, the actual percentage of comber waste removed was determined by collecting and weighing the sliver, noils, and fly waste, the proportion that the weight of the noils comprised of the total being used as a basis for the percentage. The following tabulation shows the settings used, the specified percentages of waste, and the actual percentages obtained.

Setting of cushion plate to detaching roll (inches)	Specified percentage of waste	Actual percentage of waste
0.24 1/	2/	0.57
.24	4	3.93
.33	8	7.77
.39	12	12.17
.42	14	13.96
.44	16	15.75
.46	18	18.35
.48	20	19.81
.52	24	24.20

1/ Top combs were removed for this lot.
2/ Smallest percentage possible.

A 40-grain comber sliver was made for the lot combed with a 16-percent waste removal, no attempt being made to control the sliver weights for the other lots.

The comber sliver from these 9 lots, together with one lot of card sliver, was passed successively through one process of drawing, a slubber,

an intermediate, and a fine frame, making a quantity of 5.50 hank, 7.35 hank, and 10.00 hank fine frame roving. Using double roving in the creel of a conventional draft spinning frame, a quantity of 22s, 36s, and 60s warp yarn was then spun from each of the 10 lots of cotton. Also, a separate doff of soft-twisted 36s yarn (3.00 twist multiplier) was spun, and wet-twisted into 36/2 yarn with a ply twist multiplier of 2.73. (This yarn corresponds to a mercerizing yarn construction rather than the higher twist construction usually employed in the manufacture of army uniform twill, but it is believed that essentially the same relationships would hold true for practically all constructions.)

Using 25 skeins of 22s and 36/2, 35 skeins of 36s, and 50 skeins of 60s from each lot, the yarns were conditioned for at least 4 hours at 65 percent relative humidity and 70° Fahrenheit, and tested for strength and size. Samples of the 22s and 60s from each lot were wound on black boards and graded for appearance, using the standards developed cooperatively by the American Society for Testing Materials and the United States Department of Agriculture.

Fiber length arrays were made with the use of the Suter-Webb cotton fiber sorter on samples of the raw cotton, comber lap, of each lot of comber sliver, and of the comber noils or waste from each lot. From the data obtained from these tests, the length at the 25-percent point in the cumulative array, the mean fiber length, and the coefficient of variation of length were calculated for each lot. Such information was obtained to determine just how combing altered the fiber length distribution of the cotton in each case.

To learn whether the physical characteristics of fineness and percentage of immature fibers were altered in the combing process, tests of fineness (fiber weight per inch) and immaturity (percentage of thin-walled fibers) were made of the comber sliver and noils from each lot.

RESULTS OF TESTS

Fiber Tests

The fiber length data, and the results of the tests of fiber fineness and immaturity are shown in table 1. The length data for the various lots of sliver are also shown graphically in figure 1.

With an increase in percentage of comber waste, both the length at the 25-percent point in the array and the mean length of fiber in the comber sliver increased in a fairly consistent manner. Between 0.57 and 24.20 percent in comber waste, the length at the 25-percent point increased 0.017 inch, or about 1/64 of an inch, while at the same time the mean length increased 0.064 inch, or just over 1/16 of an inch. In other words, the mean length increased more rapidly, because of the fact that more and more short fiber was being removed as waste. This is definitely reflected in the coefficients of length variation, which gradually decreased from 27.06 to 20.89 percent as approximately 24 percent more waste was removed.

Table 1.--Fiber length at upper 25-percent point in array, mean length, fineness, and immaturity for raw cotton and comber lap, and for comber sliver and noils produced when different percentages of waste were removed at the comber

Sample	Comber waste	Length 1/		Coefficient of variation	Fineness (weight per inch)	Immature fibers
		25-percent point	Mean			
	Percent	Inches	Inches	Percent	Micrograms	Percent
Raw cotton	0	1.224	0.998	30.90	3.85	25.73
Comber lap	0	1.207	1.008	28.13	4.23	27.25
Comber sliver...	0.57	1.216	1.022	27.06	4.09	27.50
Comber sliver...	3.93	1.226	1.049	25.19	3.95	25.72
Comber sliver...	7.77	1.238	1.059	24.53	4.04	25.33
Comber sliver...	12.17	1.230	1.059	24.02	4.10	25.31
Comber sliver...	13.96	1.272	1.084	23.61	4.01	25.87
Comber sliver...	15.75	1.246	1.068	23.70	4.18	22.74
Comber sliver...	18.35	1.263	1.087	22.58	4.09	26.75
Comber sliver...	19.81	1.239	1.082	21.31	4.08	22.48
Comber sliver...	24.20	1.233	1.086	20.89	4.12	23.16
Comber noils....	0.57	.886	.596	59.82	3.89	37.44
Comber noils....	3.93	.928	.658	51.74	3.93	37.27
Comber noils....	7.77	.968	.674	50.69	3.83	35.16
Comber noils....	12.17	1.009	.722	46.29	3.78	33.08
Comber noils....	13.96	.984	.709	46.78	3.96	33.98
Comber noils....	15.75	1.009	.739	45.30	4.06	37.75
Comber noils....	18.35	1.030	.741	45.36	4.10	36.56
Comber noils....	19.81	1.012	.742	44.39	3.85	33.09
Comber noils....	24.20	1.027	.764	41.86	4.07	31.99

1/ Average of two length arrays.

A careful examination of the length data shows that two of the lots, namely, those from which 13.96 and 18.35 percent of comber waste had been removed, were slightly out of line with regard to fiber length, being noticeably longer than the adjacent lots. No explanation of these departures from the general trend is at hand, and they must be ascribed to the mechanical vagaries of the comber and to the limited number of tests.

From the standpoint of the theory and objectives of combing it is rather surprising to note that even highly combed cotton is little more uniform in length than is uncombed cotton. A coefficient of variation of length of 20.89 percent is appreciably lower than the average of 27 percent found for American upland ginned lint, but the array data show that 39 percent, by

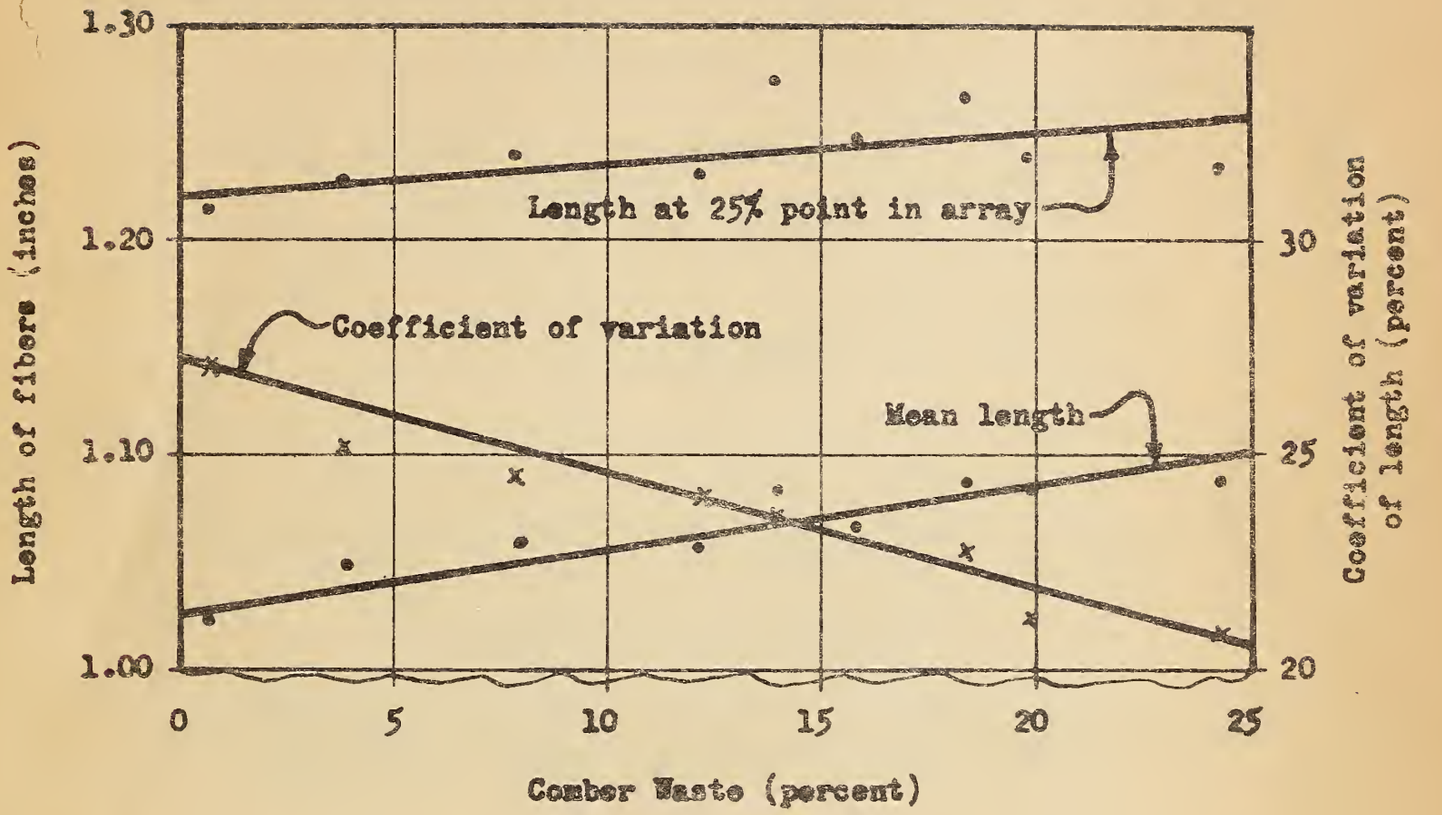

Figure 1.—Length of fibers at 25-percent point of array, mean length, and coefficient of variation for comber sliver associated with different percentages of comber waste.

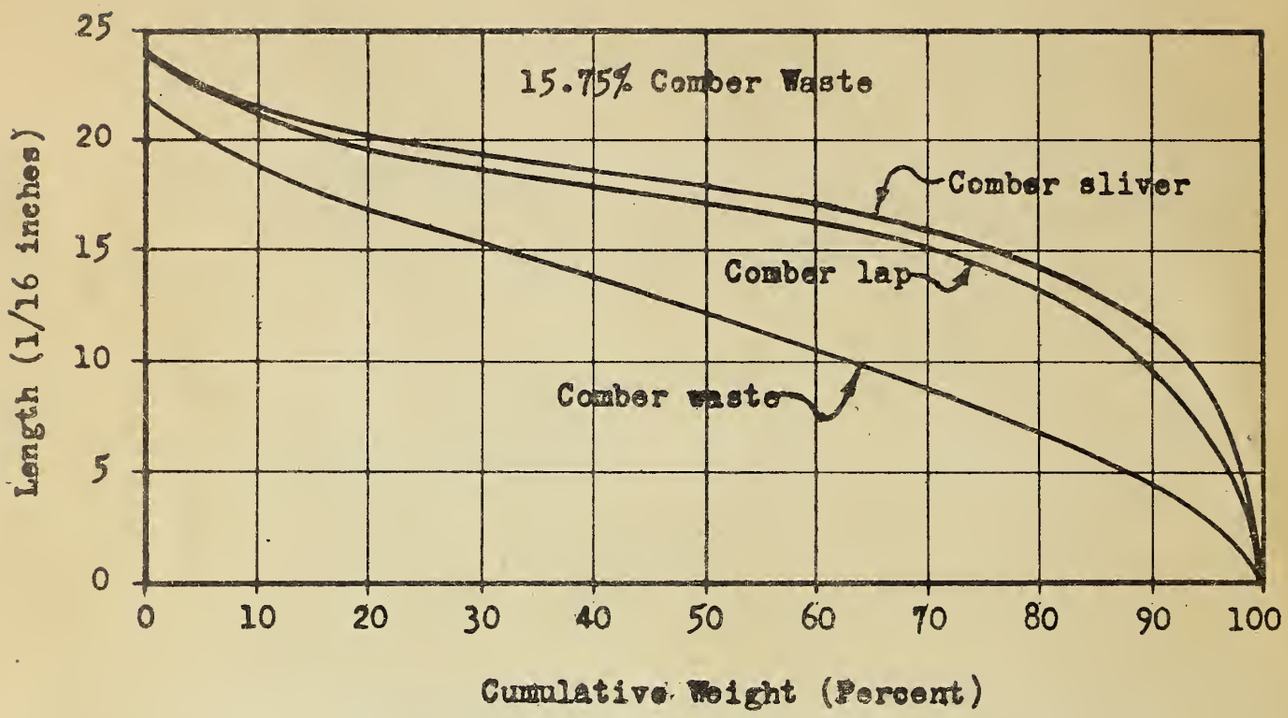

Figure 2.--Fiber length distribution of comber lap, sliver and waste (15.75 percent waste removed in combing)

weight, of the fibers in the most highly combed sliver in the test were 15/16 inch or shorter in length. At the same time, 41 percent of the weight of the fibers in the noils were 1-1/16 inches or longer in length.

Another way of demonstrating the effects of combing on the length of the fibers is by plotting the cumulative frequency curves of the cotton before and after combing. These are shown for the lot combed with 15.75-percent waste in figure 2, which also shows the curve for the comber waste. If all the fibers in the sliver were of the same length, the curve would become a horizontal straight line. In actual practice this is far from the case, and the curves for sliver and lap are fairly close together.

With regard to fiber fineness, the data for slivers and noils are fairly constant for the lots from which different amounts of comber waste were removed. Variations among the different lots tend to obscure any slight trend in fineness with increasing percentages of waste. It may be concluded, therefore, that as far as this test is concerned, the comber showed no significant tendency to segregate the fibers with respect to fiber weight.

The machine appears to be rather selective, however, with respect to fiber wall type. There were relatively more thin-walled or immature fibers in the waste than there were in the sliver, and as the waste percentage increased, the proportion of thin-walled fibers in the sliver tended to decrease. At the same time the fibers in the waste became more "diluted" with thick-walled or mature fibers as the waste increased.

If immature fibers are detrimental to the dyeing or mercerizing quality of the yarn or to the serviceability of the fabric, it is evident that combing effects a slight improvement in the stock from this standpoint.

Yarn strength

The average skein strengths of the yarns spun from stock from which different proportions of comber waste had been removed are shown in table 2. These strengths have also been plotted in figure 3, and straight lines have been fitted to the plotted points by the method of least squares.

It will be noted that there is a definite trend toward stronger yarns for higher percentage of comber waste. The rate of increase in terms of pounds of strength is greater in the coarser yarns, but from a relative standpoint the finer yarns show a slightly greater increase in strength.

Considering the lot from which 0.57 percent comber waste had been removed as 100 percent with respect to yarn strength, the average percentages of the 4 counts have been calculated for the other lots. These percentages are plotted in figure 4, which provides the most significant facts of the study. Again a straight line has been drawn, as representing the probable true relationships of waste to yarn strength.

Table 2.--Average skein strengths of carded yarns and of combed yarns made from stocks having different percentages of comber waste removed

Test lot	Average skein strength of yarn 1/			
	36/2	22s	36s	60s
	Pounds	Pounds	Pounds	Pounds
Carded	137.88	116.60	62.60	31.74
Combed:				
0.57 percent waste	142.40	120.44	64.66	32.16
3.93 percent waste	146.56	122.24	66.57	33.40
7.77 percent waste	151.72	124.32	65.94	33.70
12.17 percent waste	153.28	126.16	69.60	35.70
13.96 percent waste	157.96	129.32	69.37	35.60
15.75 percent waste	155.40	126.84	70.17	34.62
18.35 percent waste	160.72	129.44	71.31	37.40
19.81 percent waste	159.24	129.88	71.31	35.70
24.20 percent waste	157.56	133.72	72.40	36.68

1/ Each value is the corrected average skein strength of 25, 25, 35, and 50 skeins, respectively, for 36/2, 22s, 36s, and 60s yarn.

In actual mill practice, it is likely that, on an average, from 15 to 16 percent comber waste would be taken out of cotton of 1-5/32 inch staple. The practical range of interest in this particular test probably extends from 10 to 20 percent in comber waste. From figure 4, it may be seen that there was an increase in yarn strength from 106 to 111.3 units for the comber waste percentage range of 10 to 20 percent, or a difference of 5.3 units. This is exactly a 5-percent strength increase; therefore, it may be concluded that a 10-percent increase in comber waste results in a 5-percent increase in yarn strength, or, that a 2-percent increase in comber waste results in a 1-percent increase in yarn strength.

From large numbers of spinning tests made in the Department's laboratories, involving many different staple lengths of cotton, an equation has been developed which expresses the relationship of staple length to yarn strength for various counts of yarn. These tests have shown that, on the average, an increase of 1/32 of an inch in staple will result in an increase of about 2.5 percent in yarn strength. 2/ This being true, and since a 2.5-percent increase in yarn strength results from a 5-percent increase in comber waste, it follows that from the standpoint of yarn

2/ These tests have also shown that fiber tensile strength may be as important as length in its effect on yarn strength, and that other fiber characteristics such as fineness and maturity have an important bearing on yarn strength.

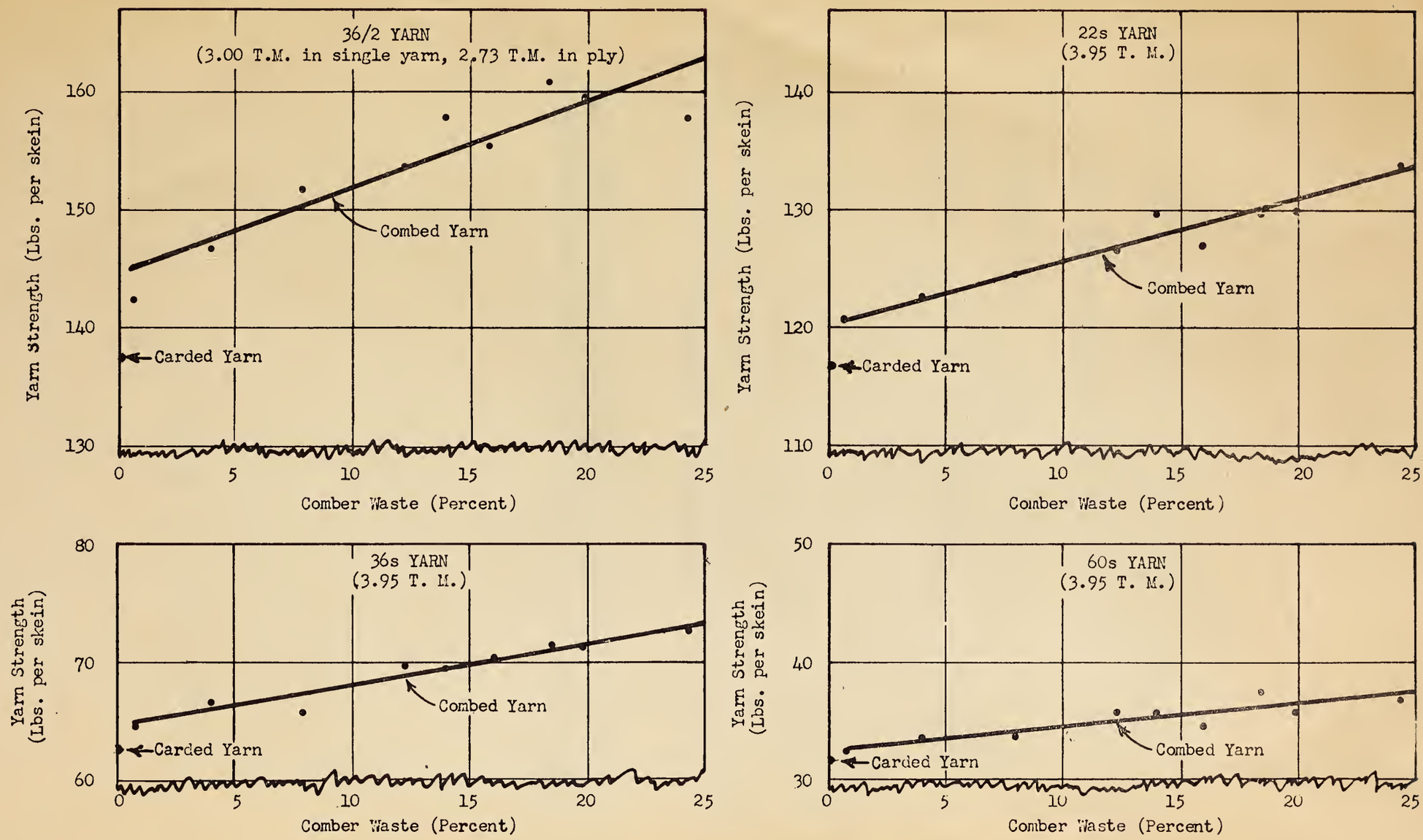

Figure 3.--Average skein strengths of 36/2, 22s, 36s, and 60s yarns and the twist multipliers used. The skein strengths are shown for yarns made from stocks from which different percentages of comber waste were removed. Carded yarn strengths are also shown.

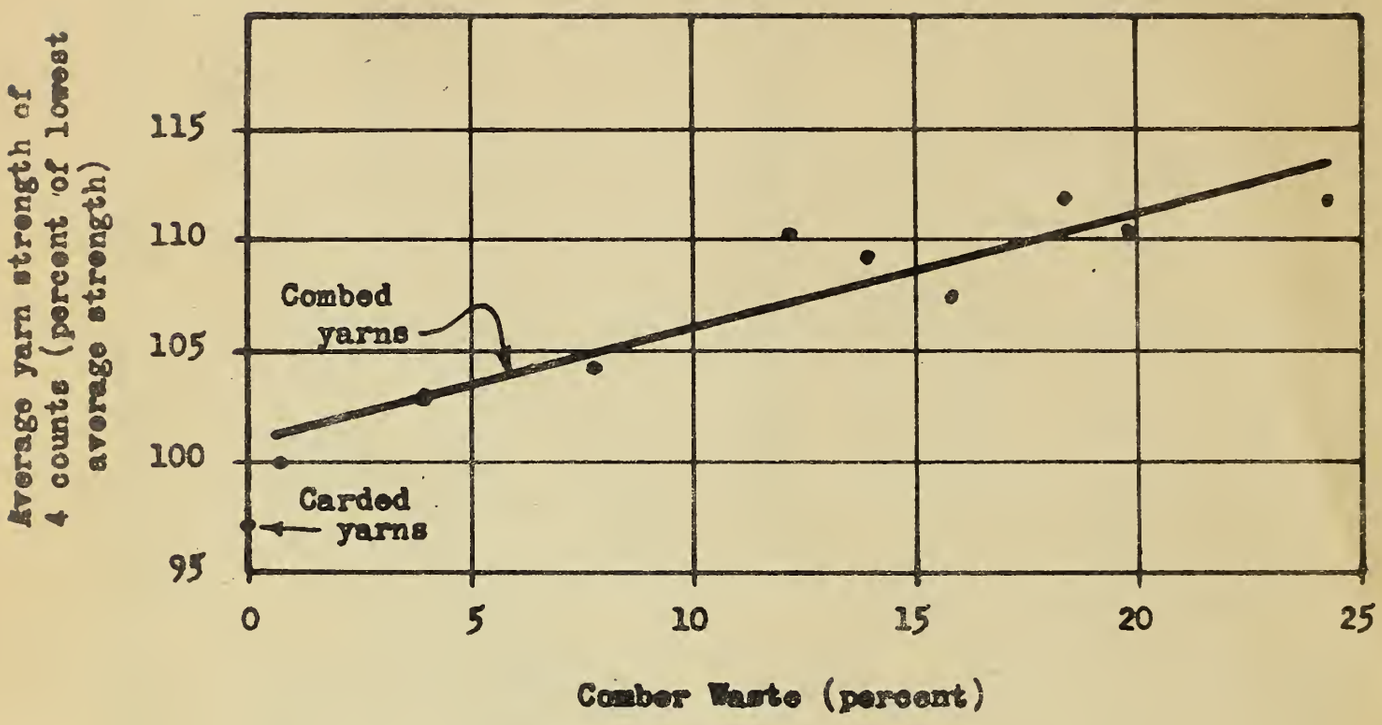

Figure 4.--Average yarn strength (in percent of lowest combed yarn strength) for cotton from which different percentages of comber waste were removed.

strength an increase of 5 percent in comber waste is equivalent to an increase of 1/32 inch in the staple length of the raw cotton. The relative cost of increasing yarn strength by taking out more comber waste and by increasing the length of staple used is discussed in a later section of this report.

The lot of cotton from which 0.57 percent in comber waste had been removed produced yarns that averaged 2.8 percent higher in yarn strength than the same counts of carded yarn. It is doubtful that this very small quantity of comber waste could have had any significant effect on the yarn strength; therefore, the increased strength may be attributed to a combination of the drafting action of the sliver and ribbon lap machines and the comber itself, plus the very slight combing the fibers may have received in their passage through the machine.

On an average, the quantity of comber waste removed in the manufacture of so-called "Peeler" yarns in commercial mills probably approximates 16 percent. At the 15.75-percent level, which is the nearest figure to that quantity in this test, it may be seen that the yarn strength was 11.6 percent higher than was that for the carded yarn.

Yarn appearance

For some purposes the manufacturer's primary objective in combing is to improve the appearance rather than to increase the strength of the yarn he spins. This is true in the case of knitting and crochet yarns, and of yarns to be used for fine dress fabrics, such as organdies or voiles. It is important, therefore, to determine how yarn appearance is affected by the removal of different amounts of comber waste.

Table 3 shows the appearance grades for the 22s and the 60s yarns. For the 22s, the grade of the yarn immediately increased from B, for carded yarn, to B+ even with the lowest comber waste percentage, and remained at that level, with slight variations, for all the combed lots. In the case of 60s, the appearance improved two-thirds of a grade, from C+ for the carded to B for the combed yarn with 7.77-percent waste, where the grade remained constant until the highest amount, 24.20 percent, was removed from the cotton. The finer count, 60s, is probably more sensitive to appearance changes than the coarser yarn, and thus may be considered a better index of the relationship of comber waste to yarn appearance. On such a basis, therefore, it may logically be inferred that the maximum improvement in this characteristic is reached at a relatively low point in comber waste removal, namely, at about 8 percent. Although for each of the two counts, one of the higher percentages was associated with one-third higher yarn grade, this did not occur at the same percentage of comber waste, and thus may be attributed to experimental variations.

This phase of the tests indicates that yarn appearance is not significantly improved by increasing comber waste within the range of percentages commercially used.

Table 3.--Appearance grades for yarns spun from cotton combed with different percentages of comber waste

Test lot	22s yarn	60s yarn
	Grade	Grade
Carded	B	C+
Combed:		
0.57 percent waste	B+	B-
3.93 percent waste	B+	B-
7.77 percent waste	B+	B
12.17 percent waste	B+	B
13.96 percent waste	B+	B
15.75 percent waste	B	B
18.35 percent waste	A-	B
19.81 percent waste	B+	B
24.20 percent waste	B+	B+

SIGNIFICANCE OF FINDINGS

On the basis of the results of these tests it appears that: (1) An increase of 5 percent in the amount of comber waste taken out is equivalent, as far as yarn strength is concerned, to an increase of 1/32 inch in the staple length of the cotton used; and (2) within the common range of comber waste percentages, the appearance of the yarn is not improved by increasing the waste percentage.

In general the principal reason a manufacturer has for increasing his comber waste is to increase the strength of his yarn. The same end result may be obtained by using a longer-stapled cotton of the same character. That is, as far as yarn quality is concerned, it makes no difference which of the two methods is used. The question then arises, is it more economical to increase comber waste, or use cotton of longer staple?

In answering this question both the mill production costs and the cotton prices must be considered.

Generally speaking, the cost of producing a pound of comber sliver from comber lap varies inversely with the production per hour of the machine. If the waste taken out by a comber is increased, the rate of production will decrease, and thus the cost per pound will increase. In addition it requires more cotton, in the semi-processed state back of the comber, to produce a pound of sliver, and this also increases the cost per pound. But comber waste itself has considerable value, so that, as more waste is

produced, this tends to offset, to some extent, the higher cost of machining the cotton when the percentage of waste is increased.

The cost per pound for comber sliver may, therefore, be determined as follows:

> Cost per pound of comber sliver = cost of semi-processed cotton to produce a pound of comber sliver + cost per pound for combing - value of comber waste produced.

In the following calculations, a figure of 2.80 cents per pound has been used to cover the cost of manufacturing from the opening process through the carding process. This figure is estimated to be representative of current manufacturing costs when spinning Delta cotton at a card production rate of 5.5 pounds per hour. A figure of 1.20 cents per pound has been used for combing, with a 15-percent waste removal. Cost of the preliminary processes, sliver and ribbon lapping, is 0.30 cent per pound.

The following equation will serve to show how the comber production, P, varies with the amount of waste, W:

$$P = \frac{P_1 \times (100 - W)}{(100 - W_1)}$$

Since cost per pound, C, is inversely proportional to production, P, the equation may be altered to

$$C = \frac{C_1 \times (100 - W_1)}{(100 - W)}$$

Thus, when the comber-waste percentage is changed from W to W_1, the cost per pound for combing changes from C to C_1 in accordance with this formula.

In individual cases, however, this relationship between cost per pound and waste may not exist. For example, the job load for comber tenders, that is, the number of machines per operative, is based to some extent on the production they handle, and, if their present job load is somewhat low, a reduction of about 5 percent in the production per comber per hour might be sufficient to warrant giving them one more machine each to tend. The labor cost per comber would then be reduced and it is possible that only the indirect labor on combing would increase per pound of production.

Other adjustments of a somewhat similar nature, such as changing the operating speeds of the machines, may sometimes be made that will offset the decrease in production of comber sliver caused by increasing the waste percentage. It is generally true, nevertheless, that costs vary inversely with production, and that as comber waste percentages increase, production decreases. Thus, for the purpose of this study the relationships described are correct.

In comparing the relative costs of improving yarn strength through increasing comber-waste percentages and through the use of longer-stapled cotton, the price of the cotton must be considered. For this purpose two series of price figures are used, one representing the latest 5-year average and the other, approximately, current prices. The value of comber waste, and corresponding figures for waste prices are likewise based on the 5-year average and the current prices.

Tables 4 and 5 are based on the principle, previously developed in this report, that an increase of 5 percent in comber waste and an increase of 1/32 inch in staple length of the raw cotton will have approximately an equal effect upon yarn strength. The lengths used in the comparisons are 1-1/8, 1-5/32, and 1-3/16 inches, which comprise the bulk of the cotton used for army uniform twills. The grades used in the comparisons are Strict Middling, Middling, and Strict Low Middling. These probably are the principal grades used for combed yarns. Table 4 shows the cost of producing a pound of comber sliver from each of the three staples and each of the three grades, using the 5-year average prices (1937-38 to 1941-42) for cotton. Table 5 shows the same kind of information for approximately current prices (December 18, 1942).

Table 4.--Cost per pound of comber sliver, by grade and staple length of cotton and percentage of comber waste, based on 5-year average prices of cotton and comber waste 1/

Staple length (inches)	Grade of cotton: Strict Middling — Comber waste (%) 10	15	20	Middling — Comber waste (%) 10	15	20	Strict Low Middling — Comber waste (%) 10	15	20
	Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents
1-1/8		23.45	24.36		22.32	23.16		20.77	21.52
1-5/32	24.14	25.05	26.07	22.99	23.83	24.77	21.28	21.46	22.26
1-3/16	25.79	26.80		24.50	25.44		21.87	22.64	

1/ Based on 5-year average prices of cotton (1937-38 to 1941-42) delivered to Group B Mill points; average comber waste price (8.88 cents per pound) for the same period, calculated from reports in the Daily Mill Stock Reporter and current manufacturing costs for Delta cotton.
Arrows connect costs of comber sliver that will produce yarns of equal quality.

Table 5.--Cost per pound of comber sliver, by grade and staple length of cotton and percentage of comber waste, based on current prices of cotton and waste 1/

Staple length (inches)	Grade of cotton: Strict Middling, Comber waste (%): 10	15	20	Middling, Comber waste (%): 10	15	20	Strict Low Middling, Comber waste (%): 10	15	20
	Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents
1-1/8		37.28	38.93		35.60	37.14		32.02	33.34
1-5/32	38.50	40.13	41.95	36.92	38.46	40.18	32.07	33.32	34.72
1-3/16	41.78	43.61		39.93	41.64		35.14	36.57	

1/ Based on price of cotton delivered to Group B Mill points as of Dec. 18, 1942; value of comber waste at 11.00 cents per pound; and current manufacturing costs for Delta cotton.

Arrows connect costs of comber sliver that will produce yarns of equal quality.

In tables 4 and 5 the arrows connect the cost figures for staples and percentages that will produce approximately the same quality of sliver or yarn. For example, for a particular grade, 1-3/16 inch staple with 10-percent comber waste, 1-5/32 inch staple with 15-percent waste, and 1-1/8 inch staple with 20-percent waste all appear to produce the same quality of product.

A study of the two tables will reveal the fact that for the two higher grades, at least, it is cheaper to use the shorter staples and to remove the higher percentages of waste. For the 5-year average, cotton prices on which table 4 was based, costs of comber sliver were 0.71, 0.67, and 0.31 cent per pound less when cotton of 1/32 inch shorter staple was used and 5 percent more comber waste was removed from Strict Middling, Middling, and Strict Low Middling grades, respectively. For the current prices used as a basis for table 5, the corresponding savings per pound of comber sliver are 1.43, 1.39, and 0.92 cents, respectively.

Therefore, if critical shortages of some lengths of staple should develop, it would be possible to change to other staples and make adjustments in the manufacture of combed yarns, within limits, without having to alter the specifications of the products.

By showing the nature and degree of improvement in yarn quality resulting from increases in waste, this study provides a basis for manufacturers to establish the quantities of comber waste they take out of cotton.

It is probably true that many manufacturers are taking out more waste than would be necessary, and are thereby increasing their costs, in their efforts to "play safe," particularly when making fabrics on Government contracts.

Mention should also be made of the part played by the variety of the cotton in determining the quality of the manufactured product. It is becoming better known that the character or, in other words, the spinning quality of cotton of a particular grade and staple, varies widely among different varieties and conditions of growth. Thus, it is possible to obtain significantly different yarn strengths by changing to another variety even though the grade and staple may remain the same. In this field, then, as well as in the field of processing, the manufacturer has considerable latitude in controlling the quality of the yarns and the fabrics.

SUMMARY

This study was conducted to determine the effects of removing different percentages of comber waste on the fiber properties, yarn strength, and yarn appearance of cotton of a quality in considerable demand for the manufacture of army uniform twill and other war materials. Cotton from a bale classed as 1-5/32 inch staple and Strict Middling grade was manufactured into carded yarns, and into combed yarns with 9 different percentages of comber waste, ranging from 0.57 to 24.20 percent, removed in processing. Although only one quality of cotton was used in these tests, it is believed that the findings are applicable to other cotton having approximately this staple length range.

As comber-waste percentages increased, the fiber lengths in the sliver became more uniform, approaching a coefficient of length variability of 20 percent for the highest percentage, about 28 percent for the comber lap, and about 31 percent for the raw cotton. The length at the 25-percent point of the array increased about 1/64 of an inch, and the mean length about 1/16 inch, for the complete range of waste percentages. Although the average fineness of the fibers in the slivers remained practically unchanged, the average content of immature fibers decreased somewhat, and these immature fibers were found to be present in the waste.

Yarn strength increased significantly even when a negligible amount of comber waste was taken out, probably because of the drafting and slight combing action of the machine. The increase in strength with greater waste percentages was fairly consistent, and averaged one percent for each 2-percent increase in waste. A 5-percent increase in waste increased the average yarn strength to the same degree as would be obtained by an increase of 1/32 inch in the staple length of the raw cotton.

Yarn appearance was approximately as good at the 8-percent level as at the higher levels of comber waste. Thus, increasing the amount of waste taken out by the comber, beyond about 8 percent, improves yarn

strength but does not noticeably improve yarn appearance.

At about the 16-percent level for comber waste, which approximates the average percentage for the so-called "Peeler" cottons, the yarn strength was 11.6 percent higher than was that for carded yarns, and yarn appearance was up as much as two-thirds of a grade higher.

For cotton of normal character, staple length of raw cotton is interchangeable with comber waste as regards the effects on yarn strength. For the range of staple lengths, 1-1/8 to 1-3/16 inches, and for comber-waste percentages ranging from 10 to 20 percent, it is more economical at current prices to increase yarn strength by removing more comber waste than it is by increasing staple length.